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Effect of the Addition of Thermally Activated Heavy Loam to Portland Cement on the Properties of Cement Stone

R. Z. Rakhimov[a], N. R. Rakhimova[b, *], A. R. Gayfullin[a], and V. P. Morozov[c]

[a] *Kazan State University of Architecture and Engineering, Kazan, Russia*
[b] *Faculty of Civil Engineering, Ton Duc Thang University, Ho Chi Minh City, Vietnam*
[c] *Kazan Federal University, Kazan, Russia*
**e-mail: nailia.rakhimova@tdt.edu.vn*

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Abstract—In the past decades, metakaolin additives synthesized by the calcination of kaolin clays have been implemented in cement systems. Their scarcity and high cost promotes the studies on the effectiveness of thermally activated additives of common polymineral clays. This article presents the results of research on the effect of thermally activated heavy loam additives to Portland cement. It was shown that additives of 5–15% heavy loam calcined at certain temperatures in the range of 400—600°C and ground to a certain specific surface area of up to 250–500 m^2/kg lead to a more significant increase in the strength, density, and water resistance of cement stone than corresponding metakaolin additives with the specific surface area of 1200 m^2/kg.

Keywords: Portland cement, mineral additive, metakaolin, heavy loam, calcination, grinding, cement stone, compressive strength, density, water absorption, coefficient of softening

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INTRODUCTION

The main mineral binder used in the manufacture of construction materials and products and in the construction of buildings and other structures has always been Portland cement, and it is expected to dominate in the foreseeable future. However, the production of its main component (clinker) is associated with a high consumption of natural mineral raw materials and energy resources and considerable volumes of CO_2 emission into the environment, whose growing content in the atmosphere will lead to a global ecological catastrophe [1]. In the cement industry, one of the most effective and recognized solutions is the development and expansion of production and employment of composite Portland cements with decreased content of the clinker part and introduction of active mineral additives, namely, so-called supplementary cementitious materials (SCM) [1–3].

At present, the mineral additive content in Portland cement is about 20%. The increase in the world production of Portland cement and the content of mineral additives to 30–40% leads to higher production volumes and wider use of the latter. The resources of the currently used mineral additives do not meet the increasing demand [1, 5]. The search for an alternative promoted wide-ranging research on the effectiveness of calcined clay additives [4–16] and, led, eventually, to the I International Conference on Calcined Clays for Sustainable Concrete held in Lausanne in 2015 [14]. High efficiency was shown by metakaolin, which is a product of the calcination of kaolin clays [2, 16–20].

However, metakaolin and calcined kaolin clays cannot be produced in sufficient amounts as pozzolanic additives for cements because of their limited deposits in many countries and regions, including Russia [20], and because of high demand in other industries and high cost. Against this background, unlimited sources of raw materials for the production of pozzolans are common polymineral clays [1, 14].

This calls for the research and the experience of application of pozzolans based on thermally activated polymineral clays such as Santorin Earth [21] natural baked clays [24], laterite [22, 23], marl [24], natural zeolite [25], volcanic ash [26], expanded clay furnace dust [27], kaolinite–bentonite [28] and illite–smectite [29] clays, clays with different kaolinite content and its complete absence [15, 17, 31], and clays with the predominance of different clay minerals [21, 32].

The varieties listed above are only a small part of common polymineral clays, which differ by deposits and compositions. At the moment, it is important to accumulate and systematize the studies on the effectiveness of clayites based on clays from different deposits having different compositions [33].

This paper presents the results of research on the effect of clayite additives based on heavy loam to Portland cement on the properties of cement stone com-